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THE POTENTIAL OF LOWER INPUT SUSTAINABLE AGRICULTURE FOR INCREASING FARM PROFITS

Joseph Havlicek, Jr.
Department of Agricultural Economics
and Rural Sociology
The Ohio State University

and

Clive A. Edwards
Department of Entomology
The Ohio State University

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Introduction

Crop yields in the U.S. have increased spectacularly over the last fifty years and yields have as much as tripled for some crops. Most of these increases have been due to the development of new crop varieties which respond well to inorganic fertilizers and to greatly improved control of pests, diseases and weeds. A major contribution has come from a greatly increased use of energy-based inorganic chemicals.

These intensive cropping practices and heavy use of chemicals have created a variety of environmental and ecological problems. The main environment effects are soil erosion, which results from decreased availability of organic matter and ground cover by weeds and cover crops, and pollution of ground and surface waters from agricultural chemicals (Edwards, 1988).

In recent years, the cost of energy-based agrochemicals has been increasing and has caused severe economic pressure on farmers. As a consequence, many farmers in the USA are tending to decrease the use of these inputs. There is evidence of this from surveys conducted in Ohio (Forster, et.al., February 8 and September 30, 1988) and New York (Buttel, et.al., 1988) (Table 1). Cost, cash flow, financial stress and lower commodity prices have created pressures toward reducing chemical and other energy-based inputs such as fertilizers, pesticides, and fuels used in cultivation (Buttel, et.al., 1986; Wagstaff, 1987; Lockeretz, et.al., 1984).

Lower costs of inputs combined with slight or no decreases in yields can result in improved overall farming profitability.

Coincidentally, lower inputs of pesticides and fertilizers would result in less contamination of ground and surface water and a reduction of other environmental effects.

Table 1. PERCENTAGE CONTRIBUTIONS OF PREFERENCES FOR CROP PRODUCTION PRACTICES, NEW YORK AND OHIO

Practice		New York State Survey1/ (599 farmers)	Ohio State Survey2/ (940 farmers)
Nutrient Source	- on farm source	65.8	9.7
	- inorganic fertilizer	20.8	90.3
Weed Control	- cultural practices	45.4	46.2
	- herbicides	42.6	53.8
Insect Control	- natural control	44.3	45.5
	- insecticides	31.8	54.5
Cultivations	- minimal tillage	39.8	46.1
	- as many as needed	49.1	52.9

Source: Buttel, et.al., 1989
1/ Farmers were asked their preference with the assumption that their choice was not to be based on economic grounds.
2/ Based on practices reported by farmers.

In conventional "high-input" farming systems, high yields can often be obtained by an insurance type of use of agrochemicals. For instance, crops which are more susceptible to pest and diseases because of lush and soft growth caused by heavy fertilizer use, can be protected by increased pesticide usage. A decrease in natural pest and disease control caused by herbicides through loss of foliar and habitat diversity can be compensated for by increased use of insecticides and fungicides. When broadcast fertilizers contribute to the incidence and growth of weeds, herbicides can be used to control them. However, how chemical inputs impact on each other when their levels are decreased is not well understood.

The terminology of farming systems which involve lower inputs of chemicals is confusing. Terms such as "organic," "biological" and "biodynamic" are used in reference to farming practices that completely exclude the use of synthetically produced fertilizers, pesticides, growth regulators or livestock feed additives. "Regenerative agriculture" includes most of the same concepts but accepts some use of synthetically produced chemical inputs. "Sustainable" and "Alternative" agricultural practices attempt to minimize the use of synthetic chemical inputs by adoption of more ecologically preferable and resource-efficient agricultural practices. All of these terms include the concept of lessening chemical inputs, but the terms "reduced-input" (Buttel, et.al., 1986; Wagstaff, 1987) or "lower-input" agriculture are probably clearer in meaning. The USDA has adopted the term "lower input sustainable agriculture" (LISA) but this has led to some confusion because the associated practices involve lower inputs of energy based chemicals; however, higher levels of knowledge and management inputs are usually necessary. Other inputs such as labor and capital investment may also increase.

In this paper sustainable agriculture is defined as: "Integrated systems of agricultural production that are less dependent on high inputs of energy and synthetic chemicals, more dependent on intensive management than are conventional systems and are economically viable." These lower-input systems are ecologically preferable and protective of the environment. In this paper these integrated systems of sustainable agriculture will be referred to as LISA systems.

Emphasis in this paper is on the overall economics at the farm level of such lower input systems and on their affects at the aggregate and market levels. Some case studies which provide evidence on the profit potentials of LISA to farmers are discussed.

Microeconomics of the Farm

Input and Output Mix

In the conversion from conventional agriculture to LISA the levels of chemical inputs are reduced, but to maintain yields or physical output levels, or at least to minimize the decrease in output levels, the levels of other inputs such as labor, management, or equipment and machinery will increase. Hence, the mix of inputs used in production will change affecting the cost of production and the cost structure of the farm firm. Furthermore, farm output may change and in the aggregate, impact the market price for a commodity. Consequently the net returns and hence profitability of the farm will be altered. This may occur because of the change in costs or because of a change in gross return or both. If LISA is to be adopted by farmers, net returns and profit realized by the farm must increase or at least not decline. In the situation where profits are not enhanced, adoption of LISA may still provide non-monetary benefits and incentives to the farmers.

Costs

First let us consider the changes which might occur in costs of production of a farm producing one or more grains when conversion is made to LISA. The levels of chemical fertilizers, herbicides, insecticides, and other chemicals is reduced. In recent years fertilizers, lime and gypsum, and chemicals have accounted for approximately 55% of the U.S. average per acre variable cash expense1/ in corn production, 40% in wheat production and about 50% in soybean production. The U.S. average per acre cash outlays for these chemical inputs are about $65-70 for corn production, $18-21 for wheat production, and $26-28 for soybean production (USDA, ERS, 1987). Comparable estimates of these costs can be obtained from the Ohio farm income data (Havlicek, Ramey, and Matthews, 1988). Reducing these chemical inputs offers substantial opportunities for reducing the per acre variable cost of production and increasing net returns per acre.

Costs of items such as storage, interest, management and labor, cultivation, and equipment and machinery may either increase or decrease. Costs of cultivation range from $9.33 to $11.53 per acre for mold board plowing, $4.28 to $4.98 for ridge cultivation and chisel plowing and $2.57 to $3.19 per acre for field cultivation (Fullen and McGuire, 1988). If the major cost of storage is for grains and total output of grains either remains the same or declines, then the cost of storage will remain the same or decline. Interest on funds borrowed for purchase of chemical inputs will decline with lower usage of chemicals but interest on funds borrowed to purchase inputs and services being substituted for chemical inputs is likely to increase. Hence, total interest cost per acre may increase or decrease. The amount of

1/ Per acre variable cash expense includes the cost of seed, fertilizer, lime and gypsum, chemicals, custom operations, fuel, lub, and electricity, repairs, hired labor, purchased irrigation water, drying, miscellaneous, and technical services. Costs not included are general farm overhead, taxes and insurance, interest paid, capital replacement, and allocated returns to owned inputs.

management and labor used per acre is likely to increase and hence the cost of management and labor per acre is likely to increase. It would be a rare situation where neither management or labor were substituted for chemical inputs. The cost of cultivation and costs of equipment and machinery for other soil preparation activities is likely to increase. There may be situations where cultivation and machinery and equipment cost per acre might remain unchanged but it is difficult to identify a situation where these costs would decline with lower chemical input use. Critical to incentives for farmers to adopt LISA systems is the balance between costs of production that decline and those that increase because of lower chemical usage. If costs that decline exceed costs that increase, there is an economic incentive to adopt LISA systems. However, the economic incentive from the cost side may still be offset by a decline in gross revenue for the commodity and eliminate an economic incentive for adopting LISA systems.

Revenues

Gross returns per acre will change if yields per acre change, price of the commodity changes, or both per acre yield and price change. Much of the data in the literature suggests that even with rather substantial reductions in the use of chemical inputs the decreases in yields are rather modest and a five percent decrease in yields per acre is a practical estimate of yield reduction. If the price of the commodity is not affected by the use of lower levels of chemical inputs and yields decline, then gross return will decline. The economic incentive for farmers to adopt LISA systems depends on whether or not the decline in costs exceeds the decline in gross return. If the decline in costs is greater, then net return will increase and it will be economically beneficial for farmers to adopt LISA systems. If the decline in gross return is greater because of the decline in yields, then net return will decline. However, if yields decline then the total output of a commodity will decline. Given that demands for grains are price inelastic, then the price of the commodity will increase by a greater percentage than the percentage decline in yields and output. Hence, gross revenue will be greater with lower yields and output. In other words, the increase in the market price of the commodity is more than compensating for the decline in yields. In the case of corn, -0.3 is a commonly accepted estimate of the price elasticity of demand for corn (Gardiner and Dixit, 1986). A five percent decline in yields would result in nearly a 17 percent increase in the price of corn assuming other variables remain nonvariant.

Legumes and Livestock

An important consideration in the conversion to LISA systems is the adoption of rotations involving legumes and grasses. Some may be used for cover and then plowed down as "green manure." But some would be marketed as hay or marketed through livestock. This introduces two important dimensions of LISA systems utilizing a rotation with legumes and grasses. First, the legumes and grasses replace grains and there will be some years during a planning period when grains will not be in the rotation. Second, the hays and grasses have to be sold for feeding livestock elsewhere or livestock enterprises have to be incorporated as part of a LISA system. Hence, costs and gross returns have to be considered from all enterprises for some specified planning period to determine whether or not net returns increase with adoption of LISA systems. There is potential for increasing net returns by using rotations and including livestock enterprises. However, raising livestock may be a deterrent to the adoption of LISA systems by some farmers. Also, considering the decline in the consumption of red meats in recent years, the prospects of increasing red meat production without adversely impacting the price of livestock may be one of the more difficult impediments to the adoption of LISA systems involving livestock.

Organically Grown Products

There are some potential profit opportunities for farmers producing commodities that are "organically" grown without the use of any chemical fertilizers or other agrochemicals. Where a market exists for these kinds of products, the products usually command premium market prices which are substantially higher than the prices of the same commodities grown using chemical fertilizers and other chemicals such as pesticides and herbicides. The financial success of producing these types of products depends critically on being able to differentiate these products in the market place from those grown with use of chemicals, understanding the demand for these products and the premium they can command in the marketplace, and recognizing and understanding the limits of the market for these differentiated products. The latter is particularly important because the markets for these products are usually limited and local in nature and offer profit opportunities for a limited number of producers who are able to operate within the constraints of these markets.

Farm Business and Household

Adoption of LISA systems may impact on the size of the farm business. Even though net returns per acre might increase, the size of enterprise that can be operated with fixed bundle of labor, management and capital resources may be less than can be operated under a conventional system. Also, net returns may fluctuate considerably from year to year because of green manures, hay crops, and other lower valued products associated with rotations in LISA systems.

The greater labor and management requirements of LISA systems may limit off-farm employment for farmers and their families. Currently, a large number of farmers and spouses are employed off the farm. LISA systems could limit such off-farm employment and potentially reduce total household income.

Case Studies of LISA Systems

There have been many studies about the components of lower input systems, such as rotations, integrated pest and disease management, alternative weed management, use of animal and plant nutrient sources and conservation and no till practices. However, only a small proportion of these have addressed the economics of adopting them. There have been fewer whole farm studies that have accounted for the overall economics of adoption of lower input practices.

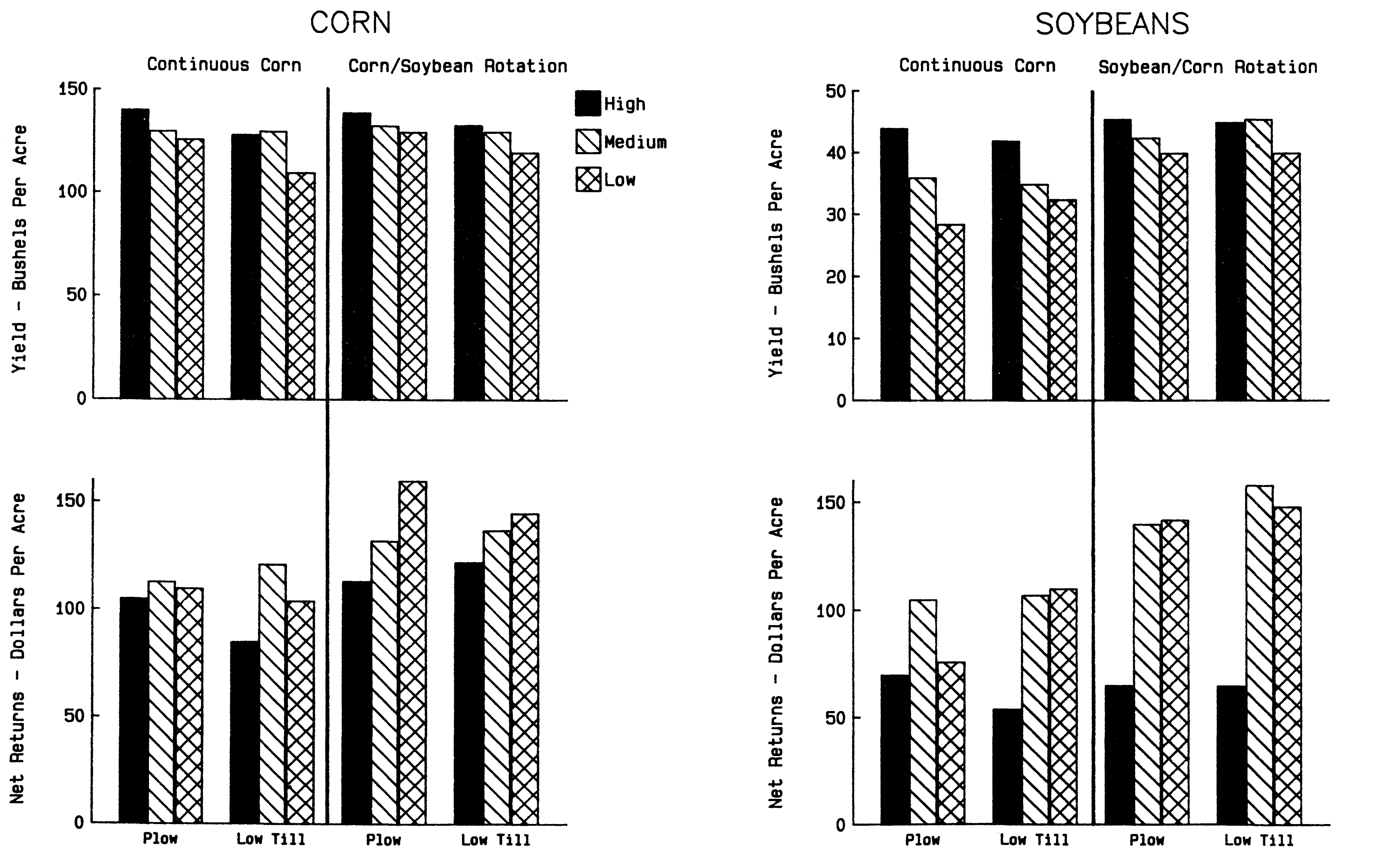
Low Input Studies in the U.S.

A project involving three different multiple cropping systems and four different pest management levels, with various degrees of intensity of pesticide use, was carried out at the University of Georgia (Tew et.al, 1982). Integrated pest management (IPM) levels of pesticide use generally resulted in lower yields than full chemical control over the period of the project, but the substantial reduction in pesticide treatment costs resulted in net returns for IPM being higher than for the conventional and alternative (organic) systems.

In a study at Urbana, Illinois the economic returns from systems involving three levels of pest management (high, medium and low) in conventional and reduced tillage on three crop rotations (continuous soybeans, continuous corn and corn and soybeans in rotation were assessed) (Figure 1). Using a risk efficiency criterion, 4 of the 18 management systems were found to be superior. These were low and medium pest management levels with either conventional or reduced tillage under a corn-soybean rotation (Zaveleta, et.al., 1984).

On the Northern Plains the economic returns from conventional and reduced tillage systems were compared with those from two lower input, sustainable systems. The two lower input systems were rotations consisting of (i) oats, alfalfa, soybeans and corn (ii) oats, sweet clover, soybeans and spring wheat and the conventional system was soybeans, spring wheat and barley. The lower input systems involved markedly lower direct costs and system (i) produced approximately the same net returns as the conventional system whereas system (ii) produced positive but somewhat lower net returns than the conventional system. Yield sensitivity studies showed that the first lower input system required yields 5-10% above those of conventional systems whereas the second system was competitive with the conventional system even when yields were 5% lower. The first system would be competitive if fertilizer and pesticide prices increased by 50%. Economic analyses

Figure 1. Yields and Net Returns for Corn and Soybeans in Illinois Using High, Medium, and Low Levels of Pesticide Inputs



indicated that reductions in farm program benefits favoring feedgrains increased the competitiveness of lower input systems (Dobbs, Leddy, and Smolik, et.al., 1987).

Variable costs and net returns from a conventionally managed rotation and a low-input legume-based rotation were compared in Washington in 1986. The conventional system was a four-year wheat/barley/wheat/pea rotation using recommended fertilizer and pesticide inputs each year. The lower-input system was a three-year pea medic/medic/wheat rotation with no pesticides except on peas. Fertilizers, pesticides and costs of application accounted for 56% of the costs for the conventional system but only 26% for the lower input system. The lower input system produced higher net returns of crops sold for market prices (Goldstein and Young, 1987).

In one study the average total production cost for conventionally-produced corn was calculated to be $323 per hectare. A lower input system involving ridge-tillage and management practices including use of animal manures and a rotation with a legume (avoiding use of insecticides) reduced production costs by about one third ($100/ha) (Pimentael, et.al., 1989).

Organic Farms in Europe and U.S.

Often yields are perceived to be less when organic farming practices are used. However, there is considerable evidence that when organic farmers have considerable management experience this may not be the case.

Relationships between levels of inputs and productivity were investigated in a study based on 493 farms in Scotland over a five-year period (Wagstaff, 1985). Using total cost (including labor) per unit of output as a criterion of performance, as many lower input farms showed above average performance as did the higher input farms. The lower input farms tended to compare favorably in terms of labor income per labor unit and rate of return on capital, but unfavorably in terms of management and investment income per hectare.

Results reported from Switzerland for three types of organic farms (arable, mixed and cattle), showed that gross returns per adjusted hectare were 93-95% of those of conventional farms (Steinmann, 1983). Direct crop costs were less than half in organic farms and total variable costs about three-quarters of those of conventional farms, so that gross margins were slightly higher and net returns per hectare about the same on biological husbandry farms as on conventional farms for organically produced products. Higher product prices are important, but the organic farms in Steinmann's study received only modest price premiums, and without these, the average gross return per hectare on the biological husbandry farms would still have been approximately 93% of those of the conventional farms. These studies provide considerable evidence that average or above-average returns per hectare margins can be obtained with low input systems.

In other studies of organic farms, despite somewhat lower yields, gross returns were as high or higher than on conventional farms. In a study of a conversion from input-intensive farming to an organic low-input rotation based system at the Rodale Research Center, Pennsylvania, USA, economic returns from organic corn were higher by the third year, despite lower yields (Culik and Liebhardt, 1984). Also, net returns per hectare on 14 organic farms in the U.S. Corn Belt, was found to be similar to that of conventional farms, with lower yields offset by lower production costs (Klepper, et.al., 1977).

European Lower Input Farming Systems

The development of integrated lower input farming systems has been most rapid in Europe (Edwards, 1988). A Study Group of the International Organization for Biological Control of noxious animals and plants, under the chairmanship of C. A. Edwards reviewed such farming systems in West Germany, The Netherlands, France and England (Vereijken, et.al., 1986). Although cropping patterns in these countries differ from those commonly used in the U.S., these reviews demonstrate principles directly applicable to lower input systems in the U.S.

A study in 1978 at Lautenbach, Stuttgart on an arable farm of 245 ha. growing cereals, sugar beets and beans compared a conventional chemical input farming system with an integrated lower input system. The lower input system involved lower inputs of fertilizers, insecticides, herbicides and fungicides, compensated for by conservation, cultivations, double-row cropping, use of pest and disease thresholds, use of organic manures and innovative techniques. The system also took account of interactions between the effects of fertilizers, cultivations and pest control techniques. The integrated system allowed inorganic fertilizer use to be decreased substantially and pesticide use to be approximately halved. Over the period 1979-1986 net returns to the farmer of the two farming systems varied annually; however, over the entire period yields and gross margins were maintained or increased. Labor, variable machinery costs and chemical costs were all less in the integrated lower input system. Clearly, this system provided economic as well as environmental incentives to the farmer.

A national experimental farm for the development and comparison of alternative agricultural systems was started in 1979 in The Netherlands at Nagele on a 72 hectare. farm. Three farming systems were compared, conventional high input farming, an integrated low input system and an organic farming system. Both the conventional and integrated systems had the same crop rotations: potatoes, sugar beets, winter wheat, whereas the organic system had a complex rotation such as potatoes, winter wheat, fodder, beets, peas, and two-year grass.

The labor costs were similar for conventional and integrated farming systems but much higher for the organic system. Fertilizer costs were almost halved and pesticide costs reduced by 90% in the integrated system over the conventional one. There was little difference in the net returns between the conventional and integrated systems but those for the organic systems were much less. When the costs of all inputs are taken into account, the integrated system performed about 18% better economically and although the organic system had the highest gross returns, it also had the highest costs and consequently the lowest net returns. This project demonstrates clearly the promising economic potential of lower input farming systems.

Aggregate Market Effects

Chemical Inputs

Concern about sustainable lower chemical input agriculture is generally at the micro level or the producing firm. However, major conversion from conventional to sustainable lower chemical input agriculture could result in several critical aggregate effects on input markets, output markets, agricultural programs, and environmental impacts at the watershed level and larger areas. The levels and mix of inputs used at the farm level will result in aggregate affects at the market level. The use of lower levels of chemical inputs in production will decrease the demand for these inputs and their prices should decrease unless other forces offset the decrease in demand. The decline in demand for chemical inputs could also have rather severe adverse impacts on agribusinesses that supply these chemical inputs at the local level. The demand for inputs being substituted for chemical inputs would increase and tend to bolster their prices upward. Labor, management, operating capital, pest monitors, biological control methods, and some types of machinery and equipment would experience increased demands and upward pressures on their respective prices.

Level and Mix of Output

With widespread adoption of LISA systems the level and mix of agricultural output would change. LISA systems would especially affect the output of feedgrains. Total output of feed grains could decrease rather substantially because of declines in yields per acre and because of legumes and other grasses in rotations there would be a reduction in acreage of feedgrains grown as compared to amounts that would be grown under conventional agricultural systems. This would result in a reduction in stocks of grain, an increasing effect on the prices of feedgrains, a possible reduction in exports of feedgrains with an associated reduction in export earnings from feedgrains, and a possible reduction in the cost of federal agricultural feedgrain programs.

Adoption of LISA systems will tend to increase the supplies of hays and grasses and lead to increased production of livestock and livestock products. Whether or not the price of hay would increase depends on whether the increase in the demands for hays and grasses, because of increased livestock production, exceeded the increase in the supplies of hays and grasses. The decline in the domestic consumption of red meats during recent years has had a depressing effect on prices of livestock and livestock products and is not compatible with tendencies to increase the production of livestock and livestock products.

Agricultural Program Costs

The reduced total output levels of feedgrains which are likely to occur with widespread adoption of LISA systems have important implications for costs of federal agricultural programs for feedgrains. Lower levels of feedgrain production, especially corn and wheat, could lead to substantial reductions in program costs and hence savings in tax dollars. Furthermore, at least part of the tax dollars saved could be used as incentives to stimulate greater use of environmentally preferable production practices associated with LISA systems and hence further enhance the incomes of farmers adopting lower chemical using production practices. This would be in addition to any benefits that farmers might receive from the reduction in taxes paid by farmers to support federal agricultural feedgrain programs.

To illustrate the potential reduction in costs of federal agricultural programs which might evolve from widespread adoption of LISA systems, let us consider only deficiency payments for corn. For the 1990 corn crop, the target price is scheduled to be $2.75 per bushel and a realistic estimate of the long-run equilibrium price for corn is \$2.00 per bushel. A reasonable estimate of the aggregate price elasticity of demand for corn is -0.3 (Gardiner and Dixit, 1986). If we consider a 1987 level of participation when deficiency payments were made on approximately 5.3 billion bushels and assume a 10 percent decrease in corn production due to a decline in yields and a decrease in acreage because of rotations in LISA systems, then the price of corn would increase by 33 percent or 66 cents per bushel and the total deficiency payments for corn would be reduced by about \$3.5 billion. At least part of this savings could be used for incentive payments to farmers to adopt LISA practices. Resource substitution, shifting of acreage and new technology that favors LISA systems relative to conventional agricultural systems would affect the magnitude of reduction in agricultural program costs. But even if one half of the above reduction in corn deficiency payments was realized, it would still be \$1.75 billion just for corn. Prices to consumers of corn based products would rise.

Environmental Impacts

Major environmental impacts evolving from conventional agricultural systems are the surface and groundwater pollution arising from the high usage of chemicals and the siltation in lakes, harbors, rivers, and drainage ditches because of the erosion associated with these practices. Nitrate and phosphate water pollution in Ohio is more severe in surface water than in groundwater. Certainly water for human consumption and many other uses of water require that water containing nitrates, phosphates and other agrochemicals receive some type of treatment prior to usage. Water treatment costs are high whether viewed from a municipal treatment plant perspective or from the perspective of a solution at a household level. Furthermore, the costs vary considerably from situation to situation depending on what kinds of chemicals are in the water and what kind of treatment is required for the particular use to be made of the water. These costs are specific to a stream, lake, other body of water or some type of watershed. LISA systems could help reduce the level of chemical content in surface and groundwater and reduce the cost of water treatment. Some farmers would be direct recipients of these benefits plus there is the potential of reducing the costs of water treatment financed from general tax funds.

Siltation due to erosion associated with conventional agricultural systems necessitate dredging and sediment management in various watersheds and lake or harbor basins. Based on a five-tons-per-acre difference in siltation between conventional and LISA systems, harbor dredging costs in the Lake Erie Basin were estimated to be about $1.88 per acre of land under conventional cultivation in the area contributing to siltation in the Lake (Hitzhusen, 1989). This estimate is based on the assumption of a 10 percent sediment delivery ratio of eroded soil and an average cost of $3.76 per ton of sediment dredged. The dredging and sediment management costs per acre will vary depending on the sediment delivery ratio and the cost per ton of sediment dredged. Furthermore, siltation in lakes and other waters where boating, fishing, and other recreational water use are adversely affected may result in lost boater values as high as $9.00 per acre for conventional agricultural systems on land contributing to the siltation problem.

Even though contributors to the siltation problem are not currently being taxed based on the amount of sediment disposed, this is not out of the realm for the future. The key point is that these dredging and sediment management costs could be reduced substantially by adoption of LISA systems and could reduce the amount of any future taxes paid by farmers. Again, some of potential costs savings could be used as incentives for farmers to adopt LISA systems and net benefits to society could still increase.

Summary and Conclusions

The microeconomic aspects of the farm firm were discussed and the major costs that would change in a conversion from conventional to LISA systems were identified. Also, major aggregate and market effects including environmental impacts of a conversion to LISA systems were identified and discussed. The costs of fertilizes and chemicals used in agricultural production comprise such a large portion of production cash expenses and provide some attractive opportunities for LISA systems to reduce production costs and increase net returns per acre. Several studies in the U.S., Europe, Germany and The Netherlands provide evidence that using lower levels of chemical inputs is economically feasible and results in increased net returns per acre or hectare. Adoption of LISA systems also may result in rather substantial reductions in costs of federal agricultural programs for feedgrains. LISA systems could lead to substantially reduced erosion and surface and groundwater pollution and consequently result in environmental benefits and benefits from reduced taxes.

Finally, a new research program dealing with the economics of sustainable agriculture is being initiated in the College of Agriculture. The objectives of the research are (1) to assess the current-level economics of sustainable agriculture in Ohio and elsewhere in the Midwest, (2) to estimate production response relationships for an important Ohio cash grain crop species, including the interaction of tillage technique, rotation, and chemical pest control, (3) to evaluate the potential downstream and groundwater benefits in Ohio of conversion to sustainable agriculture, (4) to estimate the potential economic impacts on Ohio's rural communities of conversion to sustainable agriculture, (5) to evaluate the benefits and costs of soil conservation and reduced chemical applications in selected developing countries, and (6) to identify and measure the effects of major factors influencing the demands for organically grown products and assess the market potentials for these products. This research should provide information about more profitable combinations of chemical and non-chemical inputs, income potential from organically grown products, and LISA related subsidy potentials to farmers from reductions in the aggregate supply of government subsidized commodities.

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